THE CRYSTALLITE ORIENTATION IN MESTA FIBRE

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ABSTRACT. The orientations of crystallites in mesta fibres raw, delignified and treated with different concentrations of caustic soda have been studied. The Hermans' orientation factor, the average angle of orientation and angle for 40% intensity for five samples have been determined from intensity distribution curves of the equatorial arcs in the X-ray diffraction photographs. It has been observed that for mesta, the average angle of orientation varies from 11° to 14° and Hermans' orientation factor varies from 0.91 to 0.94.

INTRODUCTION

Mesta, a substitute fibre for jute, has its crystalline structure similar to that of jute. It has been established that in jute fibres, the crystallites have their '*b*' axis nearly parallel to the fibre axis making a small angle. The other axes of the crystallites are randomly oriented. The average angle of orientation is generally measured from the distribution of intensity along the arcs into which the diffraction spots are drawn. These have been measured for cotton, jute, ramie etc. The relation between orientation and physical properties for cotton has been studied by many workers. Sen and Wood (1949) studied the orientations for jute and ramie. They compared Hermans' orientation factor and half maximum intensity angle for jute and ramie. They also observed a difference in orientation factors for different varieties of jute.

The present work was undertaken in order to study the orientation factor for mesta fibre and compare it with established values of cotton, jute and ramie, and also to investigate the variation in orientations in the raw and delignified fibres and fibres treated with different strengths of caustic soda. The Hermans' orientation factor, the average orientation angle and angle for 40% intensities were determined.

PROCEDURE

Samples of alkali treated fibres were prepared by treating raw mesta fibre with different strengths of NaOH solution. Delignified samples were prepared in the usual way by the 'Textone' process. X-ray diffraction photographs were taken for all samples with C_uK_α radiation (nickel filtered) from a Hadding type

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X-ray tube. The camera used was a flat casette plate camera. Photographs of moderate intensity suitable for microphotometer work were taken.

Following Hermans *et al.* (1939) a series of microphotometer curves of (002) and composite (101) and (10$\bar{1}$) interferences were recorded starting from the equatorial lines of the diffraction photographs and proceeding in radial lines at angular intervals of 2°30′. Densities of the photometer curves were converted into intensities from a density—log intensity curve, drawn experimentally by comparison with the curve of a standard calibration strip having intensities at various points proportional to the distance from zero intensity point. From these, curves were drawn for intensities against angular distances with equatorial lines for the (002)

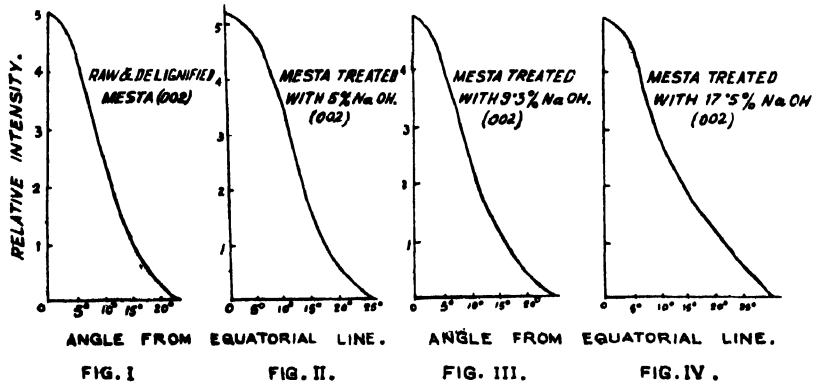

FIG. I FIG. II. FIG. III. FIG. IV.

reflections. The curves are shown in Figs. I-IV. These intensity distribution curves represent the statistical distribution of the paratropic planes of the crystallites of the fibres. Intensity may be designated by $I = F(\alpha)$ where α is the angular distance from the equator. According to Hermans the average angle of orientation α_m is given by

$$\sin^2 \alpha_m = \sin^2 \alpha_1 + \sin^2 \alpha_2$$

$$\overline{\sin^2 \alpha_1} = \frac{\int_0^{\pi/2} F(\alpha_1) \sin^2 \alpha_1 \cos \alpha_1}{\int_0^{\pi/2} I \cos \alpha_1 d\alpha_1}$$

and

$$\overline{\sin^2 \alpha_2} = \frac{\int_0^{\pi/2} F(\alpha_2) \sin^2 \alpha_2 \cos \alpha_2}{\int_0^{\pi/2} I \cos \alpha_2 d\alpha_2}$$

and the Hermans' orientation factor

$$f_x = 1 - \frac{3}{2} \sin^2 \alpha_m$$

In the case of raw fibres, it has been found that $F(\alpha_1) = F(\alpha_2)$; hence only $F(\alpha)$ for (002) is shown in the curves. (Only for the case of fibres treated with

17.5% NaOH both the (002) and (101) (Fig. 5) reflections were taken into consideration for calculating α_m and f_x). Empirical intensity curves were drawn

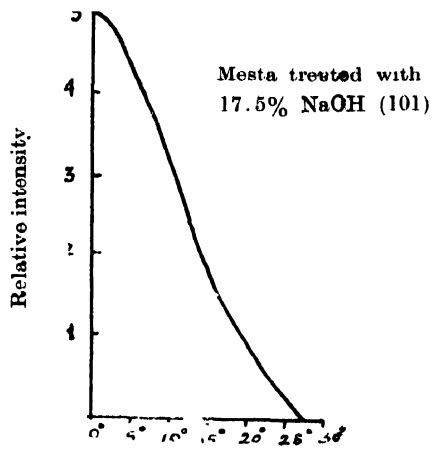

Fig. V. Angle from equatorial line.

by plotting the values of $I \sin^2 \alpha \cos \alpha$ and $I \cos \alpha$ against angular distances and the usual method of graphical integration of both curves were done. The ratio of integrals were then found out. From these, $\overline{\sin^2 \alpha_m}$ were determined and from them α_m and f_x were evaluated. Values of angles at 40% intensity were also determined from the intensity distribution curves.

RESULTS AND DISCUSSION

In Table I are given the values of f_x, α_m and angle at 40% intensity in the intensity distribution curves for (002) reflections. The results obtained show that the average angle of orientation α_m and f_x do not change substantially till

TABLE I

Showing the average angle of orientation, 40% intensity angle and Hermans' orientation factor

Sample	Average angle of orientation	40% intensity angle	Hermans' orientation factor	
Raw mesta	11.6°	11.0°	0.940	
Delignified mesta	11.6°	11.0°	0.940	
Raw mesta treated with 5% NaOH	10.5°	10.8°	0.950	
Raw mesta treated with 9.3% NaOH	12°	11.0°	0.935	
Raw mesta treated with 17.5% NaOH	14.86° (002) 14.14° (101)	15.0° (002) 14.0° (101)	0.900 0.910	0.905

treatment with 9.3% NaOH, but for samples treated with 17.5% NaOH, the values obtained differ considerably from the former ones.

The average angle of orientation α_m and orientation factor f_x for raw mesta are found to be $\alpha_m = 11.60$ and $f_x = 0.94$, whereas the average angle for jute fibres varies from 8° to 9° approximately and f_x varies from 0.96 to 0.97 as determined by Sen and Chowdhury (1957). In the case of ramie these are given by 7°36′ and 0.973 (Hermans).

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REFERENCES

Hermans, P. H., Kratky, O., and Platzek, P., 1939, *Kolloid Zeit.*, **86**, 245.
Hermans, P. H., 1946, "Contribution to the Physics of Cellulose Fibres", Amsterdam.
Sen, M. K. and Woods, H. J, 1949, *Proc. Leeds Phil. Soc.*, **5** (II,) 155.
Sen, R. K. and Choudhury, S. K., 1957, *Textile Research Journal* **27**, 193.